Advanced heat transfer modelling of melt pool dynamics for Selective Laser Melting additive manufacturing process

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Introduction

Developing a computational simulation for Laser-based powder bed fusion process using finite element heat transfer model is very complex and challenging. The aim of this study is to develop a heat transfer model by manipulating the liquid thermal conductivity with uniform and directional correction factor. For this investigations, ANSYS Parametric Design Language (APDL) codes for simulating single-layer single-track deposition of Ti-6Al-4V material were developed. For constant correction, factor width become wider, and depth become shallower. While for directional correction factor, melt pool depth gets deeper.

Simulation Model

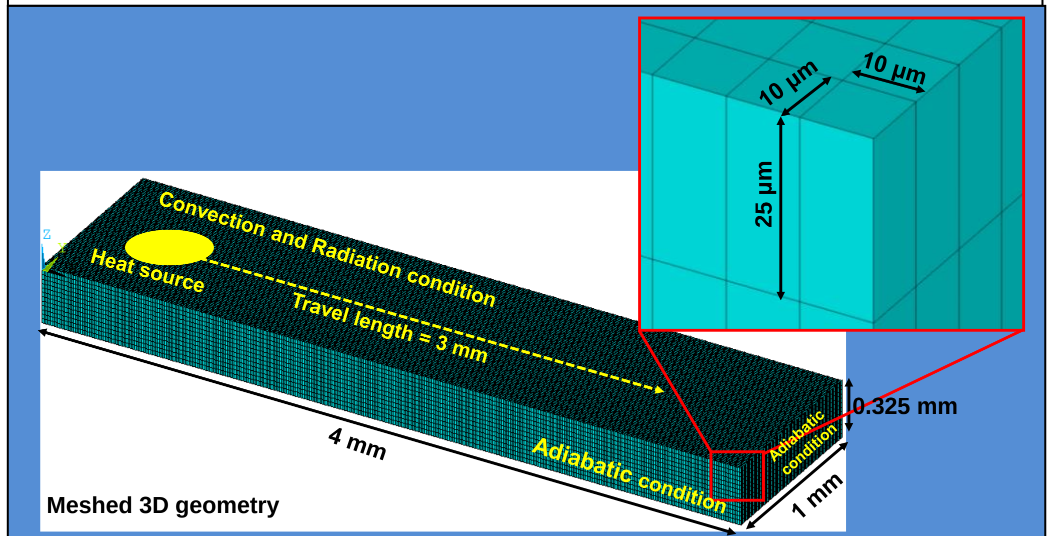
3D-Heat conduction model:

$$\frac{\partial H}{\partial t} = \nabla \cdot [K\ \nabla T]$$

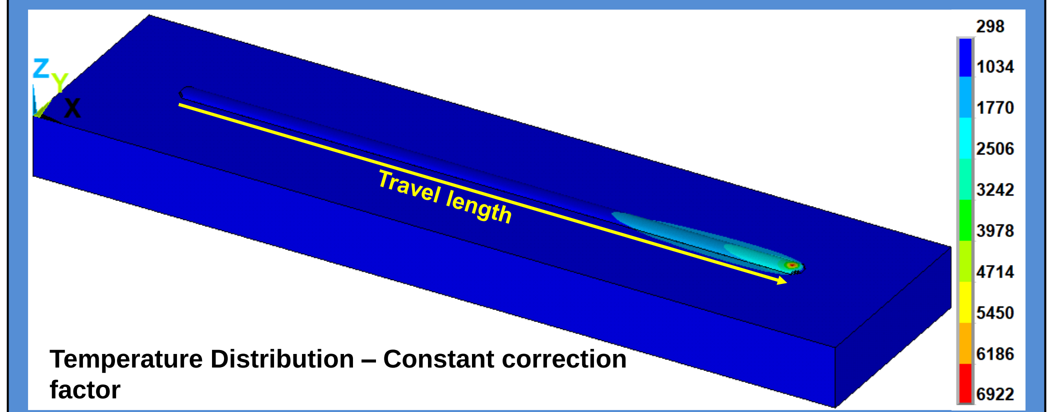
Heat source model:

$$q = \frac{2AP}{\pi R^2} exp^{\left(\frac{-2(x^2+y^2)}{R^2}\right)}$$

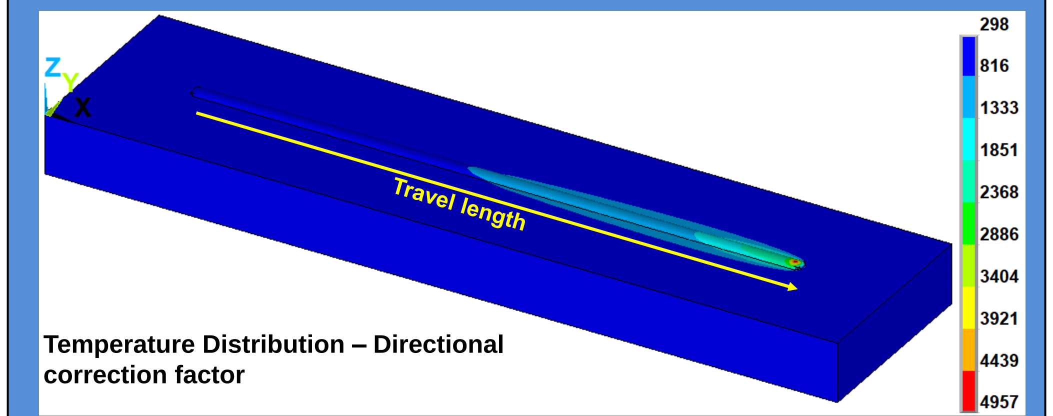
Results



Meshed 3D geometry



Temperature Distribution – Constant correction factor



Temperature Distribution – Directional correction factor

Discussion

- Constant correction factor tends to increase width and decrease the depth of melt pool therefore this can incorporate Marangoni convection phenomenon.
- Directional correction factor (i.e., different correction factor value in z-direction) tends to decrease width but increase depth. Therefore, this can incorporate recoil pressure phenomenon.

Conclusion

- Correction factor approach can be used to incorporate the fluid phenomenon in the melt pool dynamics of laser-based powder bed fusion process.
- Heat transfer model can be developed with the complex phenomenon of melt pool dynamics of laser-based powder bed fusion process.

References

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